New JWST observations reveal black holes rapidly shut off star formation in massive galaxies

April 23 2024

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New research published in *Nature* showcases new observations from the James Webb Space Telescope (JWST) that suggest black holes rapidly shut off star-formation in massive galaxies by explosively removing large amounts of gas.

The international team found that more than 90% of the galactic wind is made of neutral gas, and therefore was virtually invisible in previous studies. This work is the first direct confirmation that supermassive black holes are capable of shutting down galaxies.

The difference between this new study and previous works is found in the type of gas observed: until now it was only possible to detect ionized gas, which is warm; while the JWST was able to also detect neutral gas, which is cold.

Dr. Rebecca Davies from Swinburne University of Technology's Center for Astrophysics and Supercomputing led the Australian team behind this discovery and helped to find the powerful black-hole driven outflow in a distant massive galaxy with a very low level of star formation.

"The outflow is removing gas faster than gas is being converted into stars, indicating that the outflow is likely to have a very significant impact on the evolution of the galaxy. Our findings provide new evidence to indicate that black-hole driven outflows are able to rapidly shut off or 'quench' star formation in massive galaxies."

When star formation is quenched, it means that a galaxy has stopped forming stars. It represents the transformation between a galaxy that is actively forming stars, allowing it to grow and change, and a galaxy that is "dead" and static. Quenching is therefore a fundamental process in the life cycle of galaxies. However, astronomers still don't understand in

detail what leads galaxies to stop forming stars.

Alongside internationally recognized researchers, particularly lead author Sirio Belli from the University of Bologna, Dr. Davies studied a galaxy that is located at an enormous distance from Earth whose light took more than 10 billion years to reach us.

Active galactic nuclei (AGN)—supermassive black holes consuming large amounts of gas—can drive outflows from galaxies. The most powerful AGN drive very massive outflows that could possibly remove all of the gas from their host galaxies in a relatively "short" amount of time and cause star-formation to cease.

"The JWST made it possible for us to observe the cooler, neutral gas phase of normal AGN-driven outflows in distant galaxies. In the galaxy studied, we found that the outflow rate in the neutral phase was ~100 times larger than the outflow rate in the ionized phase, therefore revealing a lot of outflowing mass that was previously invisible."

Dr. Davies says the JWST can be used to detect a much larger fraction of the outflows, whereas previous ionized gas observations were only able to detect about 1%.

"Before the JWST, we were only scraping the tip of the iceberg when it comes to the outflowing mass."

The team is excited for what they might discover as they analyze more galaxies in the future.

More information: Sirio Belli et al, Star Formation Shut Down by Multiphase Gas Outflow in a Galaxy at a Redshift of 2.45, *Nature* (2024). DOI: 10.1038/s41586-024-07412-1

Provided by Swinburne University of Technology